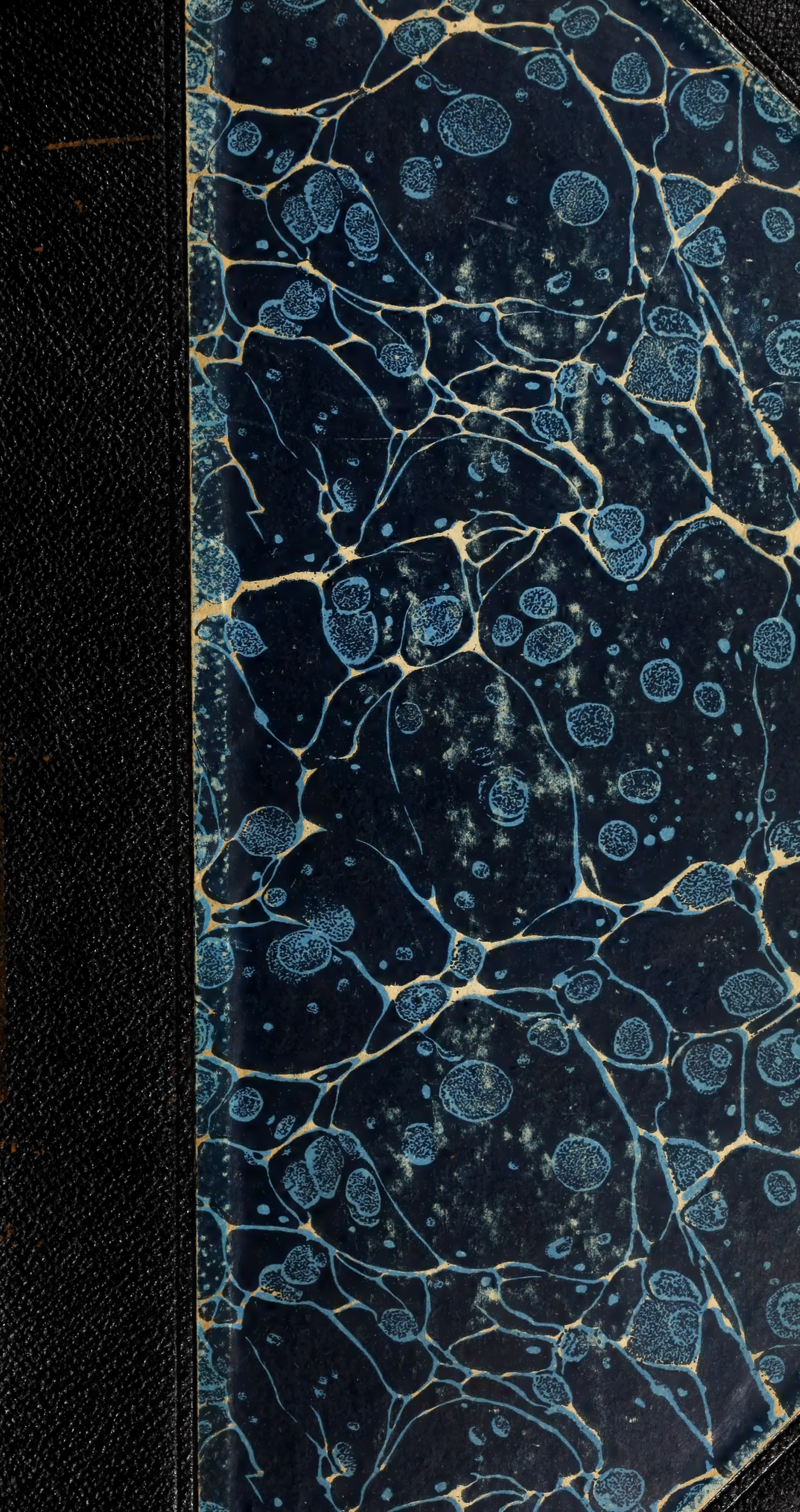

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EFFECTS OF MUTILATING THE SEEDS ON THE GROWTH AND PRODUCTIVENESS OF CORN.

By E. B. Brown,[1] *Agronomist, Corn Investigations, Office of Cereal Investigations.*

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PREVIOUS INVESTIGATIONS OF THE EFFECTS OF THE REMOVAL OF FOOD RESERVES FROM SEEDS.

The effects of the removal or suppression of portions of the food reserves of the seed upon germination and upon the subsequent growth and development of the plant have been investigated extensively. Following is a brief account of some of the experiments that are more or less analogous to those reported in this bulletin.

Sachs (*5*)[2] was perhaps the first to germinate embryos of maize detached from the endosperm. They developed dwarf plants that soon perished. These germinations were made during the course of investigations upon the processes of germination, and there seems to have been no attempt to extend the experiments beyond the early stages of growth.

Van Tieghem (*8*) reports that in an experiment in which he dissected the plumule, the radicle, and the cotyledons out of seeds of *Helianthus annuus*, he found that these fundamental organs not only were capable of independent growth but each was capable of regenerating the other two and developing perfect plants. In somewhat similar experiments with maize embryos from which the plumules had been dissected, he succeeded in obtaining an extensive development of adventitious roots, but without the appearance of chlorophyll in the scutellum and without any extension of that organ or the formation of adventitious buds. Plants more than a month old showed an excellent system of roots but were without stem or leaves. The isolated scutellum was incapable of independent growth.

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[1] The writer acknowledges his indebtedness to J. M. Hammerly and H. S. Garrison, of the Office of Cereal Investigations, for aid in conducting these experiments.

[2] The serial numbers (italic) in parentheses refer to "Literature cited," at the end of this bulletin.

Blociszewski (*2*), in experiments with maize, rye, oats, clover, peas, and lupines, found the isolated cotyledons were capable of independent growth but formed only roots. Only that portion of the cotyledon to which the embryonic plant had been attached formed roots. Plants from isolated embryos were weak in the early stages of growth, but developed normally as soon as favorable conditions prevailed and were scarcely distinguishable from plants from entire seeds.

Wollny (*9*) conducted both laboratory and field experiments with peas, vetches, and rye. The field experiments are of special interest because they were conducted under ordinary agricultural conditions and were carried through to the maturity of the plants. He found that the removal of one-third to two-thirds of the cotyledons or endosperm of the seeds decreased the growth and yield of the plants. The reduction in growth and in yield was in direct proportion to the amount of food reserves removed from the seeds.

Stingl (*6*), working with rye, wheat, oats, and barley, found that the isolated embryos did not develop into normal plants. Artificially nourished embryos generally did not develop so well as plants grown from normal seeds. In general, oat endosperms used as nutriment for rye, wheat, and barley embryos exercised an unfavorable influence, whereas in no instance was a like unfavorable influence observed when oat embryos were nourished with endosperms of rye, wheat, and barley.

Delassus (*3*), experimenting with beans, vetch, and lupines, from which he removed various proportions of the cotyledons, obtained results similar to those of Wollny. The height of plants, the number and dimensions of the leaves, the number of flowers per foot of vine, and the number and size of fruits were all reduced. The disease resistance was lessened.

Dubard and Urbain (*4*) concluded from their experiments with the castor bean, maize, beans, and carrot that the albumen is never indispensable to the development of the young plant. Nevertheless, the influence of the albumen is favorable and appears to be particularly useful during the first days of germination.

Urbain (*7*) describes in detail experiments with Ricinus, Nigella, and Papaver and states that other experiments with maize and oats gave analogous results. He summarizes the effects of suppressing the food reserves of the seed as follows: (*a*) Dwarfing the plants; (*b*) causing very apparent morphological modifications in the leaves; (*c*) causing a precocious but sparse flowering, in some instances the only flowering, in others followed by a second flowering at the normal period; and (*d*) causing frequent sexual anomalies in the course of the first flowering.

Andronescu (*1*) conducted experiments with maize in the laboratory and in the field. In the laboratory he dissected out the embryos, detaching them from the scutella, and succeeded in germinating them upon various nutrient solutions. He found that "the stem produced was the expansion of the mesocotyl and the elongation of the plumule sheath. One principal and two secondary roots, very poorly developed, were produced. In no case was the plumule able to split its sheath."

In the field experiments the embryos were not detached from the scutella and the plants were grown to maturity. The stalks from the embryos were shorter, of smaller diameter, and of fewer internodes than the stalks from the entire seeds. In general, the ears of the stalks from embryos were borne at lower nodes than the ears of the stalks from entire seeds. The ears from both the control and the test plants were imperfectly developed because of unfavorable weather during the growing season. No comparison of yield is shown.

The experiments that have been reviewed have dealt principally with plants other than corn; they have been conducted largely in the laboratory or greenhouse and frequently have not extended to the maturity of the plants. In some of the experiments the seed has been sown in the greenhouse and the plants later transferred to the field. These experiments would not be entirely representative of field conditions. In those that have been conducted under field conditions, corn either has not been among the species worked with or where it has been included the data obtained are incomplete.

EXPERIMENTS ON THE EFFECTS OF MUTILATION OF THE SEED COATS AND ENDOSPERMS.

The experiments reported in this bulletin, with the exception of those on the effect of mutilation of the embryo, were entirely under field conditions. The purpose was to determine the effects upon growth and productiveness that may be expected in a general way to result from the use of seed which from various causes is deficient in food reserves. These experiments are of additional interest because of the data they furnish upon the influence of the physiological condition of the seed in predetermining the subsequent development of the plant.[3]

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[3] This subject has been interestingly discussed and reviewed by Kidd and West, Physiological Predetermination, in Annals of Applied Biology, v. 5 and 6, 1918, 1919.

In 1917 the experiments were conducted at the United States Experiment Farm, San Antonio, Tex., the Giles Farm, Waco, Tex., and the Yarrow Plant-Introduction Field Station, Rockville, Md.; in 1918 at the Rockville station; in 1919 at the Rockville station and at the Arlington Experimental Farm, Rosslyn, Va., near Washington, D. C.

PREPARATION OF THE SEEDS.

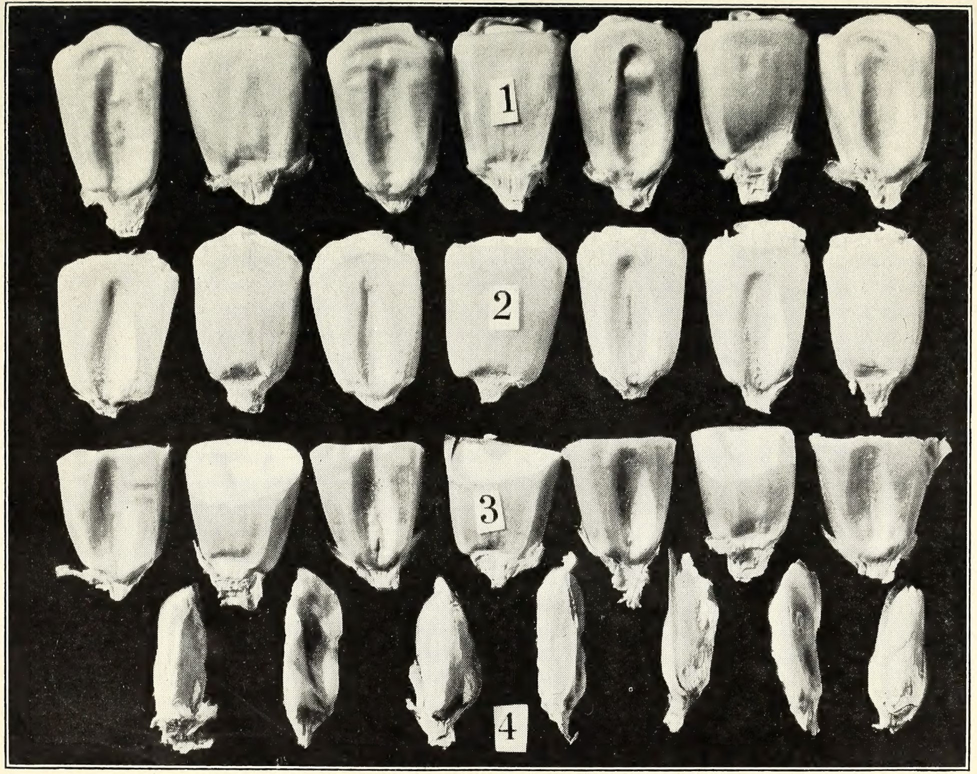
The preparation of the seeds used in the experiments conducted during the period from 1917 to 1919 was as follows: Four lots of seed were composited from four ears of United States Selection No. 119, a white dent variety, in such a manner that each ear was represented in the same proportions in each of the four lots. One lot received no injuries and was the "entire seed" or "check" (Pl. I, fig. 1), of the experiments. In the second lot (Pl. I, fig. 2), the seed coats, or hulls, were entirely removed. In the third lot (Pl. I, fig. 3), the crowns were cut off and as much of the soft starch removed as could be done without breaking the kernels. The hulls were not removed except the portion cut away with the crown. In the fourth lot (Pl. I, fig. 4), the entire endosperm was removed, leaving the isolated germ. The germ in the sense used in this article is the combined scutellum and embryo. The same methods of preparing the seed were followed each year. The different classes, for convenience in discussion, are termed check, dehulled, starchless, and germs.

PLAN OF THE EXPERIMENTS.

The plan of planting was the same each year and at all places. The following list shows the arrangement of the rows and the kind of seed planted in each row:

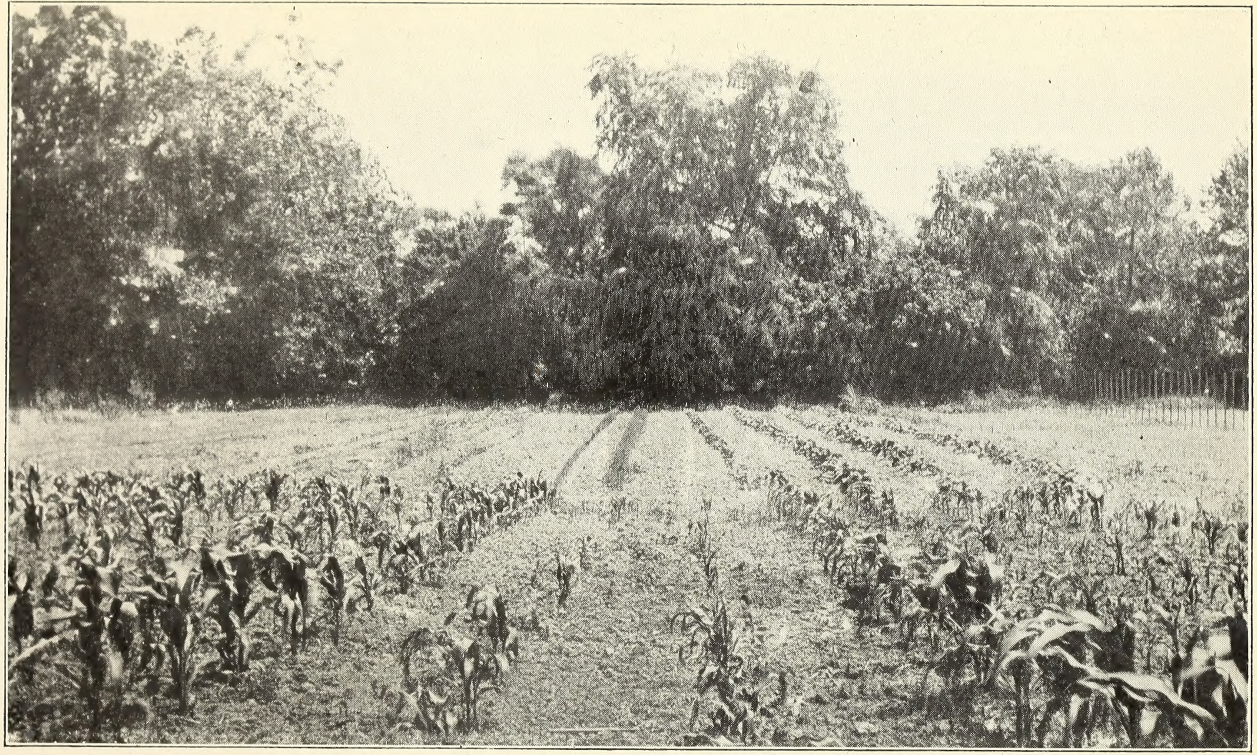
Row No. 1. Guard, United States Selection No. 119.
2. Entire seed.
3. Hulls removed, dehulled.
4. Hulls removed, dehulled.
5. Entire seed, check.
6. Soft starch removed, starchless.
7. Soft starch removed, starchless.
8. Entire seed, check.
9. Endosperm removed, germs.
10. Endosperm removed, germs.
11. Entire seed, check.
12. Guard, United States Selection No. 119.

The distance between rows and between hills in the row was 3.3 feet except at San Antonio, where the distance was 4 feet and 3.5 feet, respectively. The number of hills in each row varied from 22 to 25. The rate of seeding was four kernels to the hill, and the stands were thinned to two plants. No fertilizers were used.



KERNELS OF CORN SHOWING THE CHARACTER OF THE MUTILATIONS OF SEED COAT AND ENDOSPERM.

Fig. 1, entire kernels; fig. 2, kernels with hulls removed; fig. 3, kernels with soft starchy portion removed; fig. 4, endosperm removed, leaving isolated germ.



EXPERIMENTAL PLAT OF CORN GROWN FROM MUTILATED SEEDS IN 1917 AT THE YARROW PLANT-INTRODUCTION FIELD STATION, ROCKVILLE, MD.

The two rows of plants shown in the middle of the illustration are from the dehulled seeds; the immediately adjacent row on either side is from entire seeds.

In harvesting, the stalks and suckers in each row were counted and the numbers recorded. The approximate average height of plants in each row was recorded. Each row was harvested separately and the ears weighed, counted, and classified into good and poor. If there appeared to be significant differences in moisture content the total product of each row was dried and the compared yields were based upon the dry weights. The plats were harvested from 140 to 155 days after planting.

EXPERIMENTAL DATA ON THE EFFECTS OF THE MUTILATION OF THE SEED COATS AND ENDOSPERMS.

The data presented in tabular form are dates of planting, emergence, and harvesting; ratio of actual stand to the possible stand three weeks after seeding; number of days from emergence to the first pollen shedding; number of plants per row when harvested; total and average weight of ears; total number of ears; average number of ears; and yield and corrected yield for each plant.

The corrected yield of a row was calculated by the formula $X = AB \div Y$, in which A is the actual yield of the row, B the average yield of all the check rows; Y the computed check yield for the row, and X the corrected yield of the row. In computing check yields for each row, the difference between the yields of two adjacent checks is divided by the number of intervening rows plus one and this quantity added to or subtracted from the yield of the successive checks as computed.

SAN ANTONIO EXPERIMENT.

The data from the San Antonio experiment are incomplete because of the effect of a long drought. Plantings were made on May 17. This late planting was necessary because the soil moisture previous to that date was not sufficient to insure the germination of the seed. The germination was rapid and uniform. Perfect stands were recorded on May 24 from the check seed and the starchless seed, but in the rows from dehulled seed and from germs there were a number of missing hills.

No differences were observed in the size and vigor of the seedlings from the check and the starchless seed. Those from the dehulled seed were smaller and less vigorous than the checks. Those from the germs were the smallest and least vigorous; they remained smaller than the other lots for several weeks, but at harvest were not noticeably smaller. The plants from the dehulled seed at maturity averaged slightly taller than the check.

The date of pollen shedding was the same for the four lots, beginning 52 days after the plants had emerged. There apparently were no differences in the time of ripening, probably differences that may have existed in this respect being concealed by the effects of the drought. Although the plants made a fair growth, attaining a height of 6 to 10 feet, they failed to produce ears, and no data upon yields could be obtained.

WACO EXPERIMENTS.

The results obtained at Waco, Tex., presented in Table I, show that the stands three weeks after planting varied from 56 per cent of a perfect stand for the dehulled class to 98 per cent of a perfect stand for the check. Plants grown from the dehulled seed and from the germs averaged two days later than the check in date of first pollen shedding. Differences in time of ripening were not apparent. Drought sufficiently severe to reduce yields 50 per cent prevailed and may have prevented differences in maturity from becoming evident. In height of plants at maturity the check and starchless classes averaged the same, while the dehulled and the germ classes were slightly shorter than the check. The weight of ears from the mutilated lots is less than from the checks and the number of ears to the plant less except in the dehulled class. The differences in yield per plant are small but seem directly attributable to the mutilation of the seed.

ROCKVILLE EXPERIMENTS.

The results obtained at the Yarrow Plant Introduction Field Station, Rockville, Md., in 1917, presented in Table I, show that the stands two weeks after planting varied from 44 per cent of a perfect stand from the dehulled seed to 91 per cent of a perfect stand from the check seed. The number of days from emergence to pollen shedding and the dates of ripening indicate that the development of the plants was retarded by the injuries to the seed. In height of plants, the dehulled and germ classes were shorter than the check and the starchless slightly taller. The average weight of ears from the mutilated seed is less than from the check in every comparison. The number of ears to the plant is greater in the mutilated classes than in the adjacent checks, with one exception. The average yields for each plant show reductions with but one exception, where one row from the germ class slightly outyielded the adjacent check row. The relative height of the plants from germs and those from entire seeds six weeks after emergence are shown in Plate II.

TABLE I.—*Data from the seed-mutilation experiments at Waco, Tex., Rockville, Md., and Rosslyn, Va., in 1917, 1918, and 1919.*

Locality and seed planted.	Ratio of actual to possible stand (per cent).	Time from emergence to shedding of first pollen (days).	Number of plants at harvest.	Ears harvested.				Yield per plant (pounds).	
				Weight (pounds).		Number.			
				Total.	Average.	Total.	Per plant.	As harvested.	Corrected to check.
At Waco, Tex., in 1917:[a]									
Check	98	78	39	8	0.210	38	0.976	0.205	0.180
Dehulled[b]	....	....	....	....	....	....	....	....	....
Do	56	80	33	6	.182	33	1.000	.182	.170
Check	97	78	48	9	.191	47	.980	.187	.180
Starchless	95	78	38	6	.167	36	.948	.158	....
Do	93	78	44	6	.171	35	.796	.136	[c].143
Check	99	78	49	9	.209	43	.878	.184	.180
Germs	57	80	42	5	.147	34	.810	.119	....
Do	63	80	36	5	.161	31	.862	.139	[c].141
Check	99	78	48	7	.167	42	.876	.146	.180
At Rockville, Md., in 1917:[d]									
Check	88	64	49	33.7	.614	55	1.121	.689	.614
Dehulled	45	69	29	17.5	.500	35	1.206	.604	....
Do	43	68	25	15.5	.517	30	1.154	.620	[c].576
Check	95	63	45	28.0	.667	42	.934	.622	.614
Starchless	79	65	43	17.0	.378	45	1.046	.395	....
Do	79	65	47	18.0	.464	39	.830	.383	[c].445
Check	91	60	39	17.7	.680	26	.667	.454	.614
Germs	67	66	39	20.7	.543	38	.974	.531	....
Do	51	66	46	18.0	.474	38	.826	.391	[c].504
Check	91	60	45	31.0	.586	53	1.177	.689	.614
At Rockville, Md., in 1918:[e]									
Check[f]	99	....	42	....	....	....	....	....	....
Dehulled	78	....	48	19.0	.453	42	.875	.396	....
Do	73	....	45	15.5	.443	35	.778	.345	[c].384
Check	98	....	45	21.5	.615	35	.778	.478	.516
Starchless	95	....	48	20.0	.540	37	.770	.417	....
Do	95	....	50	25.0	.569	44	.880	.500	[c].489
Check	99	....	43	21.0	.568	37	.860	.489	.516
Germs	83	....	42	16.5	.485	34	.810	.393	....
Do	92	....	45	18.5	.440	42	.934	.411	[c].402
Check	97	....	44	25.5	.567	45	1.023	.580	.516
At Rosslyn, Va., in 1919:[g]									
Check	....	65	48	47.7	.994	48	1.000	.994	.976
Dehulled	....	68	46	41.1	.857	48	1.043	.894	....
Do	....	68	48	39.0	.780	50	1.041	.813	[c].898
Check	....	66	48	41.3	.844	49	1.021	.860	.976
Starchless	....	66	46	43.1	.918	47	1.021	.938	....
Do	....	66	49	39.4	.838	47	.960	.804	[c].913
Check	....	66	47	47.2	.926	51	1.085	1.005	.976
Germs	....	69	47	41.8	.836	50	1.065	.890	....
Do	....	69	46	40.0	.870	46	1.000	.870	[c].837
Check	....	66	44	46.0	.940	49	1.114	1.045	.976

AVERAGES OF DATA FROM WACO, ROCKVILLE, AND ROSSLYN, 1917–1919.

Class of seed.	Time from emergence to shedding of first pollen (days).	Number of ears per plant.	Weight per ear (pounds).	Yield per plant (pounds).		Yield per acre (bushels).[h]
				As harvested.	Corrected to check.	
Check	68	0.961	0.585	0.571	0.572	57.2
Dehulled	72	1.012	.485	.504	.506	50.6
Starchless	70	.906	.506	.466	.497	49.7
Germs	72	.910	.495	.468	.467	46.7

[a] Seed planted Mar. 14, plants emerged Mar. 24, harvested Aug. 13, 1917.
[b] Stand destroyed by rodents.
[c] Average of the corrected yields of two rows.
[d] Seed planted May 18, plants emerged May 28, harvested Nov. 1, 1917.
[e] Planted June 6, plants emerged June 12, harvested Nov. 5 and 6, 1918.
[f] Through an error this row was not harvested.
[g] Seed planted May 17, plants emerged May 27, harvested Oct. 6, 1919.
[h] Calculated on the basis of a stand of 7,000 plants per acre and 70 pounds of ears per bushel.

In 1918 the experiment was repeated at the field station at Rockville, Md. The results, presented in Table I, show that the field stands two weeks after planting varied from 75 per cent of a perfect stand for the dehulled seed to 98 per cent for the check. No data were obtained on the time of pollen shedding, but judged from the moisture content of the ears at harvest the mutilation of the seed had retarded the maturity of the plant. The height of plants at maturity could not be correlated with the treatment of the seed. The average weight of ears in the mutilated classes was less than in the adjacent checks with one exception. The number of ears to the plant and the average yield for each plant were less than in the adjacent checks in most of the comparisons.

The experimental plantings at the Yarrow Plant Introduction Field Station in 1919 were destroyed by floods shortly after planting.

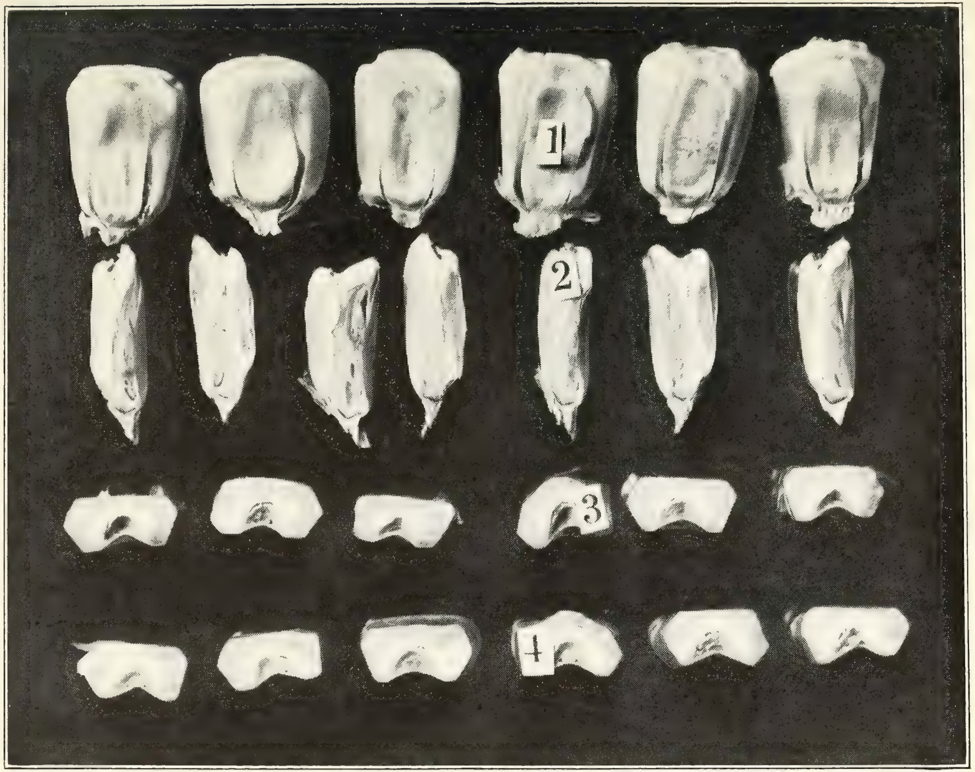
ARLINGTON EXPERIMENT.

The data obtained in the experiment at the Arlington Experimental Farm in 1919, presented in Table I, show that good stands were obtained. No counts were made, however, preceding the thinning. The dates of first pollen shedding were later in the mutilated-seed classes than in the check. The time of ripening did not appear to be materially affected. The general height of plants of the different lots at maturity did not noticeably differ. The weight of ears in the mutilated seed classes was less than from the adjacent checks except in one case. In number of ears to the plant, the dehulled class exceeded the adjacent checks in both comparisons, the starchless tied the check in one instance and was less in the other, and the germs were less than the checks in both cases. In average yield to the plant the mutilated classes were less than the adjacent checks with one exception.

EXPERIMENTS ON THE EFFECTS OF THE MUTILATION OF THE GERMS

In the experiments conducted in 1920 at the Arlington Experimental Farm the germs as well as the endosperms were mutilated. The seeds were cut into longitudinal and transverse sections. The longitudinal sections were made by cutting through from the germ side to the back of the kernel, dividing it approximately into halves (Pl. III, fig. 2); the cross sections were cut transversely to the long axis of the embryo, dividing the kernel into crown and tip portions. The crown portion contained much of the endosperm, part of the scutellum, and a small portion of the plumule (Pl. III, fig. 4); the tip contained a smaller amount of the endosperm, part of the scutellum, all of the radicle, and a portion of the plumule (Pl. III, fig. 3).

Preliminary investigations conducted in the laboratory were confined to germination tests and to observations during a short period of the early growth of the plants. In the field experiments, the



KERNELS AND SECTIONS OF KERNELS SHOWING THE CHARACTER OF THE MUTILATIONS TO THE EMBRYO AND ENDOSPERM.

Fig. 1, kernels with germs cut out and replaced; fig. 2, longitudinal half sections; fig. 3, transverse sections, tip portions; fig. 4, transverse sections, crown portions.

sectioned seeds and a third class, in which the germs were cut out and then replaced in the same kernels (Pl. III, fig. 1), were sown on fertile uniform soil and the plants grown to maturity in comparison with plants from entire seeds.

GERMINATION OF THE MUTILATED GERMS.

Two varieties of corn were used, United States Selection No. 230, a broad-kerneled yellow dent, and United States Selection No. 119, a smaller kerneled white dent. The germination tests were made in both sand and water germinators, but as the results from both were substantially the same only those made in sand are treated in detail. Of the yellow variety 38 kernels were sectioned longitudinally through endosperm and embryo, 39 kernels were cross-sectioned through endosperm and embryo, and 38 entire kernels were used as check seed. In the white variety 33 kernels were sectioned longitudinally, 25 were cross-sectioned, and 38 entire seeds were used as checks. In both the yellow and the white varieties the different classes of seed came from the same ear.

On February 1 the seeds were placed in a sand germinator and kept under favorable temperature and moisture conditions. Data obtained 10 days later on the plumule and root development are presented in Table II.

TABLE II.—*Data on the germination and the plumule and root development from entire and sectioned corn seeds at the Corn Laboratory, at Washington, D. C., in 1920.*

Variety.	Entire seeds.		Sections showing the development indicated.					
			Longitudinal sections.		Cross sections.			
					Tip portions.		Crown portions.	
	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.
United States Selection No. 230:								
Total	38		76		39		39	
Germination		100		88.2		64.0		0
Plumule and roots—								
Development good			37	48.7	15	38.5	0	
Development weak			8	10.5	4	10.2	0	
Plumule, no development; roots, fair development			22	29.0	6	15.4	0	
Plumule and roots, no development			9	11.8	14	35.9	39	100
United States Selection No. 119:								
Total	38		66		25		25	
Germination		100		83.4		92.0		0
Plumule and roots—								
Development good			50	75.8	20	80.0		
Development weak			5	7.6				
Plumule, no development; roots, fair development					3	12.0		
Plumule and roots, no development			11	16.6	2	8.0	25	100

The use of the term "good development" in Table II is entirely relative; in no instance were the plumules and roots from the sections equal in growth and vigor to those from the entire seeds. The coleoptiles and first leaves had a torn and ragged appearance, as a result of the mutilation of the seeds. There was no development of the plumule from the crown sections, but in some there were indications of growth or viability in the plumule tips contained in these sections, there was a slight swelling of the tissues and a tendency to turn yellowish green in color. This attempt to grow could not, or at least did not, persist long enough to lead to any development of the plumule or to show any tendency toward a regeneration of the roots.

Similarly, in the tip sections that showed no plumule but a fair development of the root system there did not appear to be any tendency toward a regeneration of the plumule. In the longitudinal sectioning of the seeds, portions of the plumule and of the radicle were left in each section. In the laboratory 45 seedlings showing plumule and root development were obtained from 38 seeds sectioned longitudinally in one variety and 55 seedlings showing plumule and root development from 33 seeds in another variety. This is not brought out in Table II, as the percentages are based on the total number of sections and not on the total number of seeds.

GROWTH AND SEED PRODUCTION OF THE MUTILATED GERMS.

Two varieties were used in the field experiments, United States Selection No. 182, a white dent variety, requiring about 130 to 140 days to ripen, and United States Selection No. 193, a yellow flint variety, requiring about 110 to 120 days to ripen. On May 12 entire kernels, longitudinal sections, cross sections, and kernels out of which the germs had been cut and then replaced in the same kernels were sown at the Arlington Experimental Farm, Rosslyn, Va. The injured classes were sown thickly, 15 to 20 sections to a hill. The crown and tip portions of the cross sections were not separated, but in view of the results obtained in the laboratory it seems certain that the plants in this class grew from the tip portions. The data obtained on the field experiments are shown in Table III.

In United States Selection No. 182 the plants from the longitudinal half-sections were slightly higher in average production to the plant, weight of ear, and number of ears to the plant than the plants grown from the entire seeds; the plants from the other two classes of injured seed were inferior to those from entire seeds. The plants from the cross sections were the least thrifty and were lowest in productiveness, weight of ear, and number of ears to the plant.

TABLE III.—*Comparison of the growth and yield of corn plants grown from entire and sectioned seed at the Arlington Experimental Farm, Rosslyn, Va., in 1920.*[a]

Variety.	Row No.	Date of—		Number harvested.				Production (pounds).			Number of nodes above ground.	Height (feet).	
		First pollen shedding.	First silks.	Plants.	Suckers.	Ears.	Ears per plant.	Ears.	Per plant.	Average per ear.		Plants.	To ear.
United States Selection No. 182, white dent:													
Entire kernels....................10 hills..	102a	Aug. 1	Aug. 2	20	3	22	1.10	20.0	1.000	0.910	16	9 to 10	3 to 4½
Half sections (longitudinal)......10 hills..	102b	Aug. 4	Aug. 5	14	3	16	1.14	16.0	1.140	1.000	16	9 to 10	3 to 4½
Cut out and replaced germs......10 hills..	102c	Aug. 5	Aug. 6	13	2	14	1.08	12.0	.924	.858	16	9 to 10	3 to 4½
Half sections (cross)............10 hills..	102d	Aug. 6	Aug. 7	15	0	16	1.07	11.0	.734	.688	16	9 to 10	3 to 4½
United States Selection No. 193, yellow flint:													
Entire kernels....................10 hills..	103a	July 22	July 23	20	35	23	1.15	15.0	.750	.652	11 to 14	6 to 8	1½ to 3
Half sections (longitudinal)......10 hills..	103b	July 25	July 28	20	23	28	1.40	13.8	.690	.493	10 to 12	6 to 8	1½ to 3
Cut out and replaced germs......10 hills..	103c	July 26	....do...	18	20	25	1.39	13.2	.734	.528	10 to 12	6 to 8	1½ to 3
Half sections (cross)............10 hills..	103d	July 31	Aug. 3	19	2	15	.79	5.8	.305	.305	10 to 12	6 to 8	1½ to 3

[a] Date of seeding May 12, harvested October 11, 1920.

The plants from the mutilated seeds were shorter and weaker in appearance than those from the entire seeds during the first six or eight weeks of growth. Later, the differences in height largely disappeared, and when harvested the different lots were approximately of the same average height. In general, the plants from the entire seeds were the most vigorous throughout the season, although there were exceptional plants from the injured seeds that equaled them.

In United States Selection No. 193 the plants from the injured seeds were inferior to the plants from the entire seeds in average production to the plant and in average weight of ear but surpassed the check plants in number of ears to the plant except those from the cross sections, which were inferior in every respect. The number of nodes above ground was slightly less in the plants from the injured seeds than those from the entire seed.

The data on the yields and prolificacy shown in Table III have been presented as evidence of the extent to which plants from seeds so severely mutilated could recover to a condition of normal growth and reproduction rather than as a comparison of the productivity of the different lots of seed.

SUMMARY.

The effects of the mutilations of the seed coats and endosperms may be summarized as follows:

(1) The stands were less than from the check seed. The poorest stands were obtained from the dehulled seed. This was not due to decreased viability, but evidently to weakened ability to withstand field conditions.

(2) Seedlings from mutilated seed in general were smaller than those from the check seed. The least difference was between the starchless class and the check. In some instances the seedlings from the two classes were not distinguishable in size and vigor. Seedlings from the dehulled class were noticeably smaller than those from the check seed. Seedlings from the germs were much smaller, more slender, and had narrower leaves than those from the check seed.

(3) The height of plants at maturity was not definitely affected, and it bore no consistent relation to the height of the check plants.

(4) The development of the plants was retarded, pollen shedding and ripening, in general, being later than in the checks.

(5) The average number of ears to the plant was reduced. The only exception was the dehulled class, which exceeded the check in the general average.

(6) The average weight of ears and the yield of the plant were less than in the checks. The degree of reduction was fairly consistent with the extent of the mutilations.

(7) The reductions in yield were equivalent to 7 to 10 bushels to the acre.

A summary of the results of the experiments with mutilated germs follows:

(1) The entire embryo was not essential to germination and development into normal plants.

(2) Normal plants were grown from seeds that had been cut into half sections through both the embryo and endosperm.

(3) In the laboratory 100 seedlings showing plumule and root development were obtained from 71 seeds sectioned longitudinally.

(4) The tip portions of the cross sections developed complete plants, and there was no development from the crown portions.

(5) There was no regeneration of one organ from another.

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